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The Complex Field Theory and Mass Formation—An Alternative Model to Higgs Mechanism

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Abstract

The electromagnetic force, strong nuclear force, weak nuclear force, and gravitational force are the four fundamental forces of nature. The Standard Model (SM) succeeded in combining the first three forces to describe the most basic building blocks of matter and govern the universe. Despite the model's great success in resolving many issues in particle physics but still has several setbacks and limitations. The model failed to incorporate the fourth force of gravity. It infers that all fermions and bosons are massless contrary to experimental facts. In addition, the model addresses neither the 95% of the universe's energy of Dark Matter (DM) and Dark Energy (DE) nor the universe's expansion. The Complex Field Theory (CFT) identifies DM and DE as complex fields of complex masses and charges that encompasses the whole universe, and pervade all matter. This presumption resolves the issue of failing to detect DM and DE for the last five decades. The theory also presents a model for the universe's expansion and presumes that every material object carries a fraction of this complex field proportional to its mass. These premises clearly explain the physical nature of the gravitational force and its complex field and pave the way for gravity into the SM. On the other hand, to solve the issue of massless bosons and fermions in the SM, Higgs mechanism introduces a pure and abstractive theoretical model of unimaginable four potentials to generate fictitious bosons as mass donors to fermions and $W^{\pm}$ and Z bosons. The CFT in this paper introduces, for the first time, a physical explanation to the mystery of the mass formation of particles rather than Higgs' pure mathematical derivations. The analyses lead to uncovering the mystery of electron-positron production near heavy nuclei and never in a vacuum. In addition, it puts a constraint on Einstein's mass-energy equation that energy can never be converted to mass without the presence of dense dark matter and cannot be true in a vacuum. Furthermore, CFT provides different perspectives and resolves real-world physics concepts such as the nuclear force, Casimir force, Lamb's shift, and the anomalous magnetic moment to be published elsewhere.

Keywords

Quantum Field Theory, Complex Field Theory, Standard Model, Higgs Mechanism, Bosons, Fermions

1. Introduction

The Standard Model (SM) [1] [2] [3] [4], was developed last century by several worldwide scientists and combined three of the four fundamental forces: electromagnetic force, strong nuclear force, and weak nuclear force. The model was a great success in developing the theory of particle physics, where the concepts of quarks [5] [6] [7] and Higgs bosons [8] [9], were introduced. The SM still has several limitations, where it failed to include the fourth fundamental force of gravity, covered neither the 95% of the universe's Dark Energy (DE) and Dark Matter (DM) [10] [11] [12] [13], nor mentioned the expansion of the universe [14] [15] [16]. The Complex Field Theory (CFT) 17 proposed that both DM and DE are complex fields of complex masses and complex charges, encompass the whole universe, and pervade all matter. This presumption explains the reason for failing to detect DM and DE for the last five decades, [18] [19], and presents a physical model for the universe's expansion. The CFT [17] also presumes that every material object carries a fraction of this complex field proportional to its mass, which led to understanding the physical nature of the gravitational force and its complex field. This important presumption paves the way for gravity into the SM. Higgs [8] in 1964 introduced a pure and abstractive theoretical mechanism. His mechanism went through several mathematical manipulations of gauge transformations and symmetry breaking to introduce three fictitious massless Goldston bosons that gave masses to Z and $W^{\pm}$ bosons and a massive fourth boson, which gave masses to fermions. The CFT in this paper provides a physical explanation for the mystery of the mass formation of particles. It shows how real mass can be generated from dark matter-energy interaction through the Mexican hat shape complex potential energy. The theory also offers new perspectives to several outstanding mysteries in physics such as the electron-positron pair production, which takes place only in the vicinity of heavy nuclei, where condensed dark matter is present and never in a vacuum and puts a constraint on Einstein's mass-energy relation ($E = mc^2$) that energy alone cannot generate mass without the presence of a dense dark matter and never in a vacuum. Furthermore, CFT resolves real-world physics concepts such as the nuclear force, Casimir force, Lamb's shift, and the anomalous magnetic moment to be published elsewhere.

2. Discussion

According to the complex field theory (CFT) [8], the whole universe is immersed in an ocean field of complex mass ($i\mu$) and complex charges ($\pm iq$). The field pervades the whole universe, and each material object carries a fraction of the complex mass and the complex charges in proportion to its mass and its velocity:

$$\begin{aligned} |i\mu(v,m)| &= \kappa(m) = \kappa\left[\Delta m(v) + m_o\right] \\ |iq(v,m)| &= \delta(m) = \delta\left[\Delta m(v) + m_o\right] \end{aligned} \tag{1}$$

where the absolute value of complex mass "$i\mu(v, m)$" and charge "$iq(v, m)$" on a material object are equal to $k(m_o)$ and $\delta(m_o)$, respectively when the object is at rest and each increases by "$\kappa\Delta m(v)$" and "$\kappa\Delta m(v)$" as the object's speed increases. "m_o" is the rest mass of the object. $\Delta m(v)$ is the relativistic mass increase, where $\Delta m(v) = m - m_o = (\gamma(v) - 1)m_o$, and $\gamma(v) = 1\big/\sqrt{1-(v/c)^2}$. All positively charged particles and neutral ones carry positive complex charges while negatively charged particles carry negative complex charges. The complex charges on the objects, "$iq(v, m)$" are the source for the gravitational field and the gravitational force between neutral masses. Note that the relativistic speed has a great effect on the mass, traveling with relativistic speed. The speed of a proton at the Large Hadron Collider (LHC) at the European Center for Nuclear Research (CERN) can reach up to ~99.9999991% of the speed of light [20]. Its relativistic mass can reach more than seven thousand times its rest mass and accordingly its complex (dark) mass and complex charge will dramatically increase. The complex field is nonuniformly [8] distributed in the universe. It is highly dense near heavy dynamic nuclei and large masses and lesser dense otherwise. The complex field ($\phi = \varphi_1 + i\varphi_2$) has zero spin and is expressed by the Klein-Gordan equation:

$$\left(\partial^\alpha \partial_\alpha + \mu^2\right)(\phi) = 0 \tag{2}$$

Equation (2) has the discrete plane wave solutions [21]:

$$\begin{aligned} \phi(x) &= \sum_k \left(i\big/\sqrt{2V\omega_k}\right)\left[a(k)e^{-ik\cdot x} + b^* e^{ik\cdot x}\right] = \phi^+ + \phi^- \\ \phi(x)^* &= \sum_k \left(-i\big/\sqrt{2V\omega_k}\right)\left[b(k)e^{-ik\cdot x} + a^* e^{ik\cdot x}\right] = \phi^{*+} + \phi^{*-} \end{aligned} \tag{3}$$

Note that ϕ^{*+} is not the complex conjugate of ϕ^+. The corresponding free Lagrangian for Equation (2) is:

$$\mathcal{L} = 1/2\left(\partial_\mu(\phi)\right)^2 - \left[1/2(i\mu)^2(\phi)^2 + (1/4)\lambda(\phi)^4\right] \tag{4}$$

The square bracket term is the intrinsic potential energy "V" due to the complex charges of dark matter:

$$V(\phi) = -1/2\,\mu^2\left(\phi^*\phi\right) + (1/4)\lambda\left(\phi^*\phi\right)^2 \tag{5}$$

The first term in Equation (5) is negative because of the imaginary nature of the complex mass ($\pm i\mu$). The second term is the field self-interaction, and λ is a positive scalar number. This potential energy function takes graphically the shape of a Mexican hat, shown in **Figure 1**. The height at the peak is a measure of the potential energy and the complex mass density.

The interaction Lagrangian density is [21]:

$$\begin{aligned}\mathcal{L} = 1/2\left(\partial_{\mu}(\varphi)\right)^{*}\left(\partial_{\mu}(\varphi)\right) - \left[1/2(i\mu)^{2}(\varphi)^{*}(\varphi) + (1/4)\lambda\left(\varphi^{*}\varphi\right)^{2}\right] \\ + (iq)\left[-\left\{\left(\partial(\varphi)/\partial t\right)(\varphi)^{*} - \left(\partial(\varphi)^{*}/\partial t\right)(\varphi)\right\}\right]\end{aligned} \tag{6}$$

The corresponding intrinsic interaction Hamiltonian is:

$$\begin{aligned}H = \sum_{k}\omega_{k}\left[a^{*}(k)a(k) + 1/2 + b^{*}(k)b(k) + 1/2\right] \\ + q\sum_{k}\omega_{k}\left[b^{*}(k)b(k) - a^{*}(k)a(k)\right]\end{aligned} \tag{7}$$

Operating the Hamiltonian on a state of scalar particles "ϕ_n" and antiparticles "$\bar{\phi}_n$", then:

$$\begin{aligned}H\left|(\phi_n)(\bar{\phi}_n)\right\rangle = \Big\{\sum_{k}\omega_{k}\left[a^{*}(k)a(k) + 1/2 + b^{*}(k)b(k) + 1/2\right]\left|(\phi_n)(\bar{\phi}_n)\right\rangle \\ - q\sum_{k}\omega_{k}\left[a^{*}(k)a(k) - b^{*}(k)b(k)\right]\left|(\phi_n)(\bar{\phi}_n)\right\rangle\Big\}\end{aligned} \tag{8}$$

$$\begin{aligned}H\left|(\phi_n)(\bar{\phi}_n)\right\rangle = \omega_n(n+\bar{n})\left|(\phi_n)(\bar{\phi}_n)\right\rangle - q\omega_n(n-\bar{n})\left|(\phi_n)(\bar{\phi}_n)\right\rangle \\ + 1/2\sum_{k}\omega_{k}\left|(\phi_n)(\bar{\phi}_n)\right\rangle + 1/2\sum_{k}\omega_{k}\left|(\phi_n)(\bar{\phi}_n)\right\rangle\end{aligned} \tag{9}$$

The first term indicates that as the number of particles and antiparticles increases the energy increases. The second term indicates that the energy depends on the particle numbers of the positive particles and the negative antiparticles. This means that for a neutral system the term average to zero energy contribution. The third and fourth terms are the zero-point energies for particles and antiparticles. These terms either grow to infinite energies or it is a virtual and not real [21].

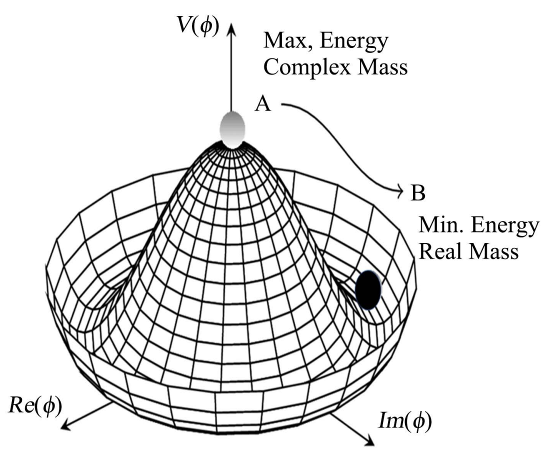

Figure 1. The Mexican hat representation of the potential energy of the complex field at every point in space.

3. Mass Formation

The Lagrangian in Equation (6) is a gauge invariant Lagrangian under global symmetry and at certain conditions, it has a local symmetry and gauge transformation as will be illustrated in special cases below. The height of the potential energy varies from one point to another depending on the potential energy level of the complex mass at the vertex. The force acting on the complex mass at any point in space is the gradient of the potential energy in Equation (5):

$$F_\alpha = -\partial_\alpha V(\varphi) = \mu^2 \varphi_\alpha - \lambda \varphi_\alpha^3 \tag{10}$$

The derivative of the potential energy $V(\varphi)$ at maximum = 0. This leads to:

$$\varphi = \pm \mu / \sqrt{\lambda} \tag{11}$$

Note that Higgs boson's mass of 125 GeV/c^2 was detected at a potential energy of 246 GeV to estimate $\lambda = 0.12$, where $\varphi = \pm \mu / \sqrt{2\lambda}$. In our case, to generate Z and W$^\pm$ of 90 GeV/c^2 and 80 GeV/c^2, respectively, the corresponding potential energy should be 177.1 GeV and 157.4 GeV and $\lambda = 3.87$, using Equation (11). This 157.4 GeV is the energy level for the conversion of up and down quarks to transform a proton to a neutron and vice versa.

The vertex of the Mexican hat potential energy "$V(\varphi)$" is always positive and the corresponding force is negative, which acts as a pulling attractive force for the complex mass ($i\mu$) towards the vertex, causing its buildup at the vertex. The buildup of the complex mass under the external force causes the instantaneous formation of massless particles starting from the tiniest elementary ones to the largest composite particles till the external force is fully exhausted. The complex massless particle at the vertex then rolls downhill as real mass to the bottom of the Mexican hat. In other words, the necessary conditions for real mass formation are the simultaneous presence of energy and complex mass.

This physical sequence of events is a must for the conversion of complex mass to real mass. This explains the outstanding mystery of why electron-positron production only takes place in the vicinity of massive nuclei, where dense complex mass exists, and the energy in Einstein's energy-mass Equation ($E = mc^2$) cannot generate mass in a vacuum without the presence of a dense complex mass, regardless of how high the energy might be.

In quantum electrodynamics, the energy density of the complex fields is:

$$u = (1/8\pi)\left[(iE)^* \cdot (iD) + (iB)^* \cdot (iH)\right] \tag{12}$$

Ignoring the magnetic effect for simplicity, the change in the energy density is:

$$\Delta u = \Delta\varepsilon \left(E^2/8\pi\right) \tag{13}$$

According to the first law of thermodynamics, this energy density should be balanced by work, which causes the complex mass to move toward the vertex.

The work per unit volume is:

$$w = p(\Delta V/V) = -p\left[\Delta(i\rho)/(i\rho)\right] \tag{14}$$

where "p" is the induced pressure and "$\Delta(i\rho)$" is the change in the complex mass density. From (13) and (14),

$$p = -\rho\left(\Delta\varepsilon/\Delta\rho\right)\left(E^2/8\pi\right) = -\zeta\left(E^2/8\pi\right) \tag{15}$$

So, the pressure is also negative at the vertex in agreement with the pulling force in Equation (10) and "ζ" is the electrostrictive coefficient. The earlier claim that massive bosons (Z and $W^{\pm}$) are created from a vacuum does not fully explain the full story of the physics that is taking place at the vertex.

3.1. Bosons and the Complex Field Theory

As mentioned earlier, the SM presumes that all bosons are massless although nature tells otherwise. The conclusion is based on the use of Proca Lagrangian for the vector potential:

$$\mathcal{L} = -(1/16)F^{\alpha\beta}F_{\alpha\beta} + \left(m^2/8\pi\right)A^{\alpha}A_{\alpha} \tag{16}$$

where "A_α" is the vector potential field and $\alpha = 0, 1, 2$, and 3. It is represented by the special orthogonal rotation group SO(3) and a spin = 1. For "A_α" to be a gauge invariant, the symmetry of the mass term in Equation (16) under the local transformation ($A_\alpha + \partial_\alpha\rho$) is examined, where $\rho = \rho(t, x, y, z)$:

$$m^2A^{\alpha}A_{\alpha} \to m^2\left(A^{\alpha} + \partial\rho\right)\left(A_{\alpha} + \partial\rho\right) \tag{17}$$

Expanding the right side to the first order in $\partial\rho$:

$$m^2A^{\alpha}A_{\alpha} \to m^2A^{\alpha}A_{\alpha} + 2m^2A^{\alpha}\partial\rho \neq m^2A^{\alpha}A_{\alpha} \tag{18}$$

The transformation is not a gauge invariant unless

$$m^2A^{\alpha}\partial\rho = 0 \tag{19}$$

Because both "$\partial\rho$" and "A" cannot be zeros, the mathematical convenience leads the standard model to let the mass $m = 0$ for all bosons although it is contrary to the experimental facts.

Instead of doubting the mathematical approach, the model denied the fundamental reality of nature. Higgs mechanism proposed mathematical gauge transformations and symmetry breaking to produce a set of fictitious massless bosons that give masses to the massive bosons, which are difficult to visualize physically. The different approach, taken by the CFT, reevaluates these mathematical models. It proves physically that the complex mass plays a major role in giving mass to massive bosons and explains that massless photons and gluons should be massless as follows:

$$m \to m + i\mu \tag{20}$$

$$A \to A + ia \tag{21}$$

Then

$$m^2A^2 \to (m + i\mu)(m - i\mu)(A + ia)(A - ia) = \left(m^2 + \mu^2\right)\left(A^2 + a^2\right)$$

Applying again the same gauge transformation:

$$\begin{aligned} A &\to A + \partial R \\ a &\to a + \partial\rho \end{aligned} \tag{22}$$

Then

$$\begin{aligned} m^2A^2 &\to \left(m^2+\mu^2\right)\left(A^2+a^2\right) \\ &\to \left(m^2+\mu^2\right)\left[\left(A+\partial R\right)^2+\left(a+\partial\rho\right)^2\right] \\ &= \left(m^2+\mu^2\right)\left[\left(A^2+a^2\right)+2\left(A\partial R+a\partial\rho\right)+\left(\partial R\right)^2+\left(\partial\rho\right)^2\right] \end{aligned} \tag{23}$$

Keeping only the first order of (∂R) and ($\partial\rho$), then

$$\begin{aligned} m^2A^2 &\to \left(m^2+\mu^2\right)\left(A^2+a^2\right) \\ &\to \left(m^2+\mu^2\right)\left(A^2+a^2\right)+2\left(m^2+\mu^2\right)\left(A\partial R+a\partial\rho\right) \\ &\neq \left(m^2+\mu^2\right)\left(A^2+a^2\right) \end{aligned} \tag{24}$$

So, the transformation is a gauge invariant transformation only if

$$\left(m^2+\mu^2\right)\left(A\partial R+a\partial\rho\right)=0 \tag{25}$$

This means that either

$$m=\pm i\mu$$

or

$$A\partial R=-a\partial\rho$$

Nature tells us that massive bosons should have mass. The first option is unacceptable but the second one is the choice, which tells that the vector potential of the real charge times its variation should balance the equivalent potential of the complex charge times its variation and of negative magnitude.

The vector potential field for a massive boson is [21]:

$$A_\alpha = 1\big/(2\pi)^3\int d^3k\left\{\left(1\big/\sqrt{2\omega_k}\right)\sum_{j=1}^{3}\left[\varepsilon_\alpha^j(k)a_j e^{-ikx}+\varepsilon_\alpha^{j*}(k)a_j^{+}e^{ikx}\right]\right\} \tag{26}$$

where the basis for the polarization vectors "ε_a" can be aligned along the axes for simplicity and take the values (1, 0, 0, 0), (0, 1, 0, 0), (0, 0, 1, 0), and (1, 0, 0, 0). "a" and "a^+" are the annihilation and creation operators.

On the other hand, massless photons induce pure real vector potential "A" and massless gluons induce equivalent complex fields "iA" due to the complex charges on the subnuclear particles. Let us assume first that both photons and gluons have mass "m" and carry the complex mass "$i\mu$", then for the photons:

$$m^2A^2=\left(m^2+\mu^2\right)(A)^2 \tag{27}$$

And for the gluons, also:

$$m^2A^2=\left(m^2+\mu^2\right)(iA)(-iA)=\left(m^2+\mu^2\right)\left(A^2\right) \tag{28}$$

Both (27) and (28) are the same. Now, applying the gauge transformations on the photons and the gluons:

$$\begin{aligned} &A\to A+\partial R \\ &\text{or} \\ &A\to iA+i\partial R \end{aligned} \tag{29}$$

Applying the gauge transformation on photons and keeping only the first order of ∂R, then

$$
\begin{aligned}
m^2A^2 &\to \left(m^2+\mu^2\right)\left(A+\partial R\right)^2 \\
&= \left(m^2+\mu^2\right)\left(A^2+2A\partial R\right) \neq \left(m^2+\mu^2\right)A^2
\end{aligned} \tag{30}
$$

Applying the gauge transformation on gluons and keeping only the first order of ∂R, then

$$
\begin{aligned}
m^2A^2 &\to \left(m^2+\mu^2\right)\left(iA+i\partial R\right)\left(-iA-i\partial R\right) \\
&= \left(m^2+\mu^2\right)\left(A^2+2A\partial R\right) \neq \left(m^2+\mu^2\right)A^2
\end{aligned} \tag{31}
$$

This means that the transformation is a gauge invariant only if

$$
\left(m^2+\mu^2\right)\left(2A\partial R\right)=0 \tag{32}
$$

This means that either

$$
\begin{aligned}
& m=\pm i\mu \\
& \text{or} \\
& A=0 \\
& \text{or} \\
& \partial R=0
\end{aligned} \tag{33}
$$

Since neither A nor ∂R cannot be zeros, the only option is that both photons and gluons are massless but carry pure complex mass "$\pm i\mu$". This agrees with the complex field theory assumption [17], which says that photons and gluons carry infinitesimal pure imaginary mass in proportion with their momenta.

The vector potential field for massless boson is [21]:

$$
A_\alpha = 1/(2\pi)^3 \int \mathrm{d}^3k \left\{ \left(1/\sqrt{2\omega_k}\right) \sum_{j=1}^{2} \left[\varepsilon_\alpha^j(k) a_j \mathrm{e}^{-ikx} + \varepsilon_\alpha^{j*}(k) a_j^+ \mathrm{e}^{ikx} \right] \right\} \tag{34}
$$

Note that it takes the same form as that for the massive boson except the sum is over 2 for the only two possible polarizations.

3.2. Fermions and the Complex Field Theory

Dirac equation

$$
i\hbar\left(\partial\psi/\partial t\right) + i\hbar c\left(\alpha\cdot\nabla\psi\right) = \beta mc^2\psi \tag{35}
$$

Using the natural units ($c = \hbar = 1$), and considering only the time and the x-components then:

$$
i\left(\partial\psi/\partial t\right) + i\alpha\left(\partial\psi/\partial x\right) = m\beta\psi \tag{36}
$$

Which can also be expressed as [22]:

$$
\begin{aligned}
i\left(\partial\psi^L/\partial t\right) + i\alpha\left(\partial\psi^L/\partial x\right) = m\beta\psi^L \\
i\left(\partial\psi^R/\partial t\right) + i\alpha\left(\partial\psi^R/\partial x\right) = m\beta\psi^R
\end{aligned} \tag{37}
$$

where ψ^L and ψ^R are the left-handed and right-handed spinning relative to the particle's momentum.

Using the matrices representation of

$$\alpha^i = \begin{pmatrix} 0 & \sigma^i \\ \sigma^i & 0 \end{pmatrix}$$

and (38)

$$\beta = \begin{pmatrix} I & 0 \\ 0 & -I \end{pmatrix}$$

β matrix acting on ψ switches its spinning orientation from left to right and vice versa. Equation (38) becomes:

$$\begin{aligned} i\left(\partial\psi^L/\partial t\right) + i\alpha\left(\partial\psi^L/\partial x\right) &= m\psi^R \\ i\left(\partial\psi^R/\partial t\right) + i\alpha\left(\partial\psi^R/\partial x\right) &= m\psi^L \end{aligned} \quad (39)$$

The mixing between the right-handedness and left-handedness in each of the equations above violates the weak charge conservation law, where the right-handed fermions (positive chirality) have weak isospin singlets ($I = I3 = 0$) while the left-handed fermions (negative chirality) have a weak isospin doublet ($I = 1/2$ and $I3 = \pm 1/2$). This mixing of left and right-handedness leads the standard model, again for mathematical convenience, to conclude that all fermions are massless. The CFT reevaluates the standard model presumption, by introducing a quartet mass matrix operator of the real mass and its complex mass along with the corresponding antimatters. The CFT considers antimatter as a substance of negative mass equal in magnitude and of opposite charge to the real matter. This consideration confirms the original definition of Dirac [23] [24], regarding electron-hole production, where the hole as an antimatter to the electron is of negative mass and has a positive charge. Note that the complex dark charges on matter and antimatter are opposite to each other and induce a real positive repelling force on each other. This repulsive gravitational force causes antimatter to behave as a substance with a negative mass to matter. The quartet mass matrix operator is:

$$M = \begin{pmatrix} m_1 & 0 & 0 & 0 \\ 0 & im_2 & 0 & 0 \\ 0 & 0 & -m_1 & 0 \\ 0 & 0 & 0 & -im_2 \end{pmatrix} = \begin{pmatrix} M_m & 0 \\ 0 & -M_m \end{pmatrix} \quad (40)$$

Dirac spinor:

$$\psi = \begin{pmatrix} \psi^1 = \text{particle} \\ \psi^2 = \text{Antiparticle} \\ \psi^3 = +\text{spin} \\ \psi^4 = -\text{spin} \end{pmatrix} \quad (41)$$

Using (39), (40), and (41), then,

$$\begin{aligned} i\left(\partial\psi^R/\partial t\right) + i\alpha\left(\partial\psi^R/\partial x\right) &= M_m\psi^R \\ i\left(\partial\psi^L/\partial t\right) + i\alpha\left(\partial\psi^L/\partial x\right) &= M_m\psi^L \end{aligned} \quad (42)$$

Equation (42) shows that the quartet concept of dark matter eliminated the mixing of right and left-handedness, preserved the mass for fermions, and conserved the law of weak charges unviolated.

4. Conclusion

The root origin for mass formation for particles has been discussed as due to the simultaneous presence of energy and complex mass. Energy alone is not enough to produce mass in the famous Einstein's Equation ($E = mc^2$) but a dense complex mass must be present. The outstanding mystery of why electron-positron pair production only takes place near heavy nuclei is now resolved where dense complex mass is present and never can take place in a vacuum. The current claim that Z and $W^{\pm}$ bosons are created from a vacuum is a wrong claim but a dense complex mass plus energy must be simultaneously present.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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